

## BACKGROUND OF THE INVENTION

### FIELD OF THE INVENTION

This invention relates to a light ignitable, energetic materials. More specifically, the invention relates to light ignitable, energetic materials containing carbon nanotubes or activated carbon containing a metal.

### DISCUSSION OF THE PRIOR ART

A carbon nanotube (CNT) is a hollow nanostructure consisting essentially of a graphitic plane rolled into a thin tube, both ends of which can be closed by a fullerene-type dome structure. The existence of CNT's was originally discovered by S. Iijima [see Nature 354, 56 (1991)]. The material exhibits various interesting mechanical and electrical properties. There exists two forms of carbon nanotubes, namely single walled nanotubes (SWNT) and multiwalled nanotubes (MWNT).

It has recently been reported by P.M. Ajayan et al in Science, Vol. 296, 705 (2002) that carbon nanotubes release a large photoacoustic effect when subjected to a flash of light caused by the absorption of the light. It seems that the phenomenon is predominantly present in SWNT's and that the temperature of the process can reach 1500°C. The inventors have also determined that activated carbon containing a metal such as palladium also possesses the property of releasing a photoacoustic effect when subjected to a flash of light.

### GENERAL DESCRIPTION OF THE INVENTION

The object of the present invention is to exploit the above described property of carbon nanotubes and activated carbon containing a metal to produce a light ignitable, energetic material.

Accordingly, the present invention relates to a light ignitable, energetic composition comprising an intimate mixture of an energetic material and one of carbon nanotubes and activated carbon containing a metal selected from the group consisting of palladium, iron, nickel, cobalt, aluminum, copper, zinc, potassium, sodium and titanium.

The invention also relates to a method of preparing a light ignitable, energetic composition comprising intimately mixing an energetic material and one of carbon nanotubes and activated carbon containing a metal selected from the group consisting of palladium, iron, nickel, cobalt, aluminum, copper, zinc, potassium, sodium and titanium.

A variety of energetic materials can be used in the method of the present invention. Such energetic materials include carbon black powder, ammonium perchlorate (AP), hexogen (RDX), octogen (HMX), pentaerythritol tetranitrate, (PETN), trinitrotoluene (TNT), nitroglycerine, nitrocellulose, ammonium nitrate, lead azide, lead styphnate, nitro plasticizers and picric acid. While the carbon nanotubes can be SWNT or MWNT, the single walled nanotubes are preferred.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

In general terms, the invention takes advantage of the photoacoustic effect of carbon nanotubes when subjected to a burst of light, e.g. a camera flash to ignite an energetic material. In order to test the theory, different carbon nanotubes were used, the most common one being a SWNT commercial available from Carbon Nanotechnologies, Inc., Houston, Texas. Different percentages of carbon nanotubes (1 - 90 weight percent) were manually mixed (gently) with carbon black powder. Initially, the most efficient composition contained 5 weight percent SWNT

mixed with 95 weight percent Grade 7 carbon black powder. The composition exploded instantaneously after being subjected to a camera flash. It was found that carbon black powder with the smallest particle size was the most effective. The same effect was observed when activated carbon containing a metal, e.g. palladium was mixed with carbon black powder, and the resulting mixture was exposed to a camera flash.

The invention will be better understood from the following examples.

#### **Example 1**

3 weight percent of crude carbon nanotubes were mixed with 97 weight percent ground ammonium perchlorate. The mixture was homogenized using ball milling equipment for 15 minutes. The balls used in the mill were made of glass. The resulting composition was then exposed to an intense flash using a commercially available Vivitar (trademark) flash. The power of the flash was 200W/cm<sup>2</sup> at a distance of 4.5 cm.

#### **Example 2**

The procedure of Example 1 was repeated using 3%, 5%, 10% and 20% carbon nanotubes. At a concentration in excess of 20% nanotubes, the ignition phenomenon was less efficient, i.e. the combustion process (explosion) appears to be incomplete.

#### **Example 3**

Energetic formulations containing carbon nanotubes and RDX, TNT, black powder or AP were ignited at distances from 3 to 7 cm using the Vivitar flash. In a few cases, ignition was possible from a distance as great as 14 cm.

#### **Example 4**

The method of Example 1 was repeated using 5 weight percent activated carbon containing palladium (97% carbon and 3% palladium) with 95 weight percent ground ammonium perchlorate. The mixture was homogenized using the same ball milling equipment as in Example 1. The composition was ignited using a flash; however, the process was less efficient than when using carbon nanotubes.

#### **Example 5**

The ignition effect was observed for a variety of mixtures of activated carbon containing 3 - 30% palladium catalyst and a variety of energetic materials. The ignition effect was similar to that observed when using carbon nanotubes, but seemed to be less efficient after 3 to 5 days. It is believed that the activated carbon was absorbing water which reduced the efficiency of the ignition phenomenon.

Compositions in accordance with the present invention can be used for light ignited pyrotechnic effects and as light ignited triggers for detonators, gas generators and air bags.

Various modifications may be made to the described embodiments without departing from the spirit and scope of the invention as defined in the appended claims.